Spatial fluctuations and localisation effects in optical characteristics of p-doped GaN films.

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In-plane uniformity of GaN films and structures is an important factor in device fabrication. Earlier we found strong in-plane nonuniformities on a sub-micrometer scale of the band edge emission in n-GaN, where the granular features were formed by the interconnected network of dislocations, also reported by other authors. In this work we explore in-plane uniformity of p-GaN films. In addition to nonuniformities similar as in n-GaN we found a new optical characteristics which we explain by a strong influence of localisation processes. This finding is important as localisation effects in GaN were anticipated earlier, but detailed evidence was not available. Localisation effects may help explain the relative immunity of GaN light emitters to structural defects brought about by lattice mismatched growth.

The measurements reported here include the optical emission spectra taken with the He-Cd laser excitation at 325 nm of p-type GaN films from various suppliers grown by MOCVD. The n-type films were also measured as a benchmark for comparison with p-type GaN. In the discussion the results of photoluminescence mapping, ODMR and photoluminescence kinetics are included as well.

The emission spectra of our p-GaN specimens generally show a broad band with the maximum at about 3.15 eV, commonly described as a blue emission band. In addition to the blue band a series of intense satellite lines appears at the high energy wing. The separation of these lines reflects the multiples of the LO phonon energy. In some samples we observe up to six such components, with the second multiple being the strongest. Polarisation studies show that each consecutive satellite line is progressively less polarised, in contrast to the Raman features, also observed. Spatial maps of the satellite lines show very rapid and strong in-plane variations, uncorrelated with one another, and there is also no visible correlation with intensity variations of the blue band, measured at the same time. The effect is not observed at other excitation wavelengths such as 488 nm, 514 nm and 810 nm, where one and two-phonon non-resonant Raman effect is observed. We note that in samples from various sources and in those that have undergone various thermal treatments the intensity of the satellite lines varies both in absolute terms and with respect to the blue band. The number of satellites that could be observed varied as well. Similar but very weak lines were observed in some of the n-GaN films.

We attribute the satellite lines to hot luminescence effect mediated by the presence of potential fluctuations, in analogy to earlier works in other materials, and we discuss the possible ramifications and consequences of this assignment. The exact source of the potential fluctuations is difficult to identify. Our data show that the blue emission band is built of several components, suggesting that a variety of donors may be present. Our ODMR measurements indicate the existence of a triplet resonance which we attribute to a Mg-O complex. Thus we establish the presence of a compensation mechanism. This compensation is credited as the main source of potential fluctuations. The photoluminescence kinetics studies of samples with varying Mg doping level show increasing decay times at increasing compensation levels, supporting that the potential fluctuations increase at high compensation.